Web-based, Multi-platform, Centralized, Offline-Compatible Supply Chain Management System for Emergency Responses

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Abstract— **The efficiency of humanitarian aid supply chains is critical to effective emergency response. In addition, a sustainable supply chain network facilitates the rapid recovery of devastated areas and provides relief for the affected populations. Thus, an efficient, reliable and sustainable emergency supply chain management system plays a critical role in the humanitarian relief operations. Currently, a typical NGO ERP (enterprise resource planning) system does not address the specific needs of emergency humanitarian relief functions. Without an emergency supply chain management system, the lack of coordination and potential human errors will cause unnecessary delays and wastes in resources, which jeopardizes the safety, and sometimes survival, of affected people. In addition, tracking relief materials from donor resources all the way to distribution to target beneficiaries is important for accountability and transparency. In this project, Purdue University and Catholic Relief Services (CRS) are co-designing a web-based, multi-platform, centralized, offline-compatible electrical emergency response system. This system is capable of connecting all global warehouses across different country programs, requesting and approving relief materials, checking inventory levels, tracking relief materials from donors to beneficiaries, and automatically generating accounting and beneficiary reports. This application will help NGOs form efficient, reliable and sustainable distribution plans for emergency responses with the most updated information.**

Keywords—humanitarian relief, supply chain, emergency response, web-based, offline-compatibility, online management system

I. INTRODUCTION

Time is a critical factor in emergency responses. To get the right humanitarian aid materials to the disaster area as soon as possible is one of the most important processes in humanitarian emergency reliefs [1][2]. Both headquarters and disaster sites of relief agencies need to know the availability, location, and transportation feasibility of humanitarian aid materials in order to form realistic distribution plans. Therefore, information systems and communication platforms for multiple organizational users from all across the world are essential to humanitarian relief [1]. However, the characteristics of humanitarian logistics are very unique compared to business logistics [2][3][4]. The demand is unpredictable. The availability of resources and involvement of suppliers are also unknown [5]. Unique characteristics such as redundancies built across the weakest link of humanitarian supply chain network, supply chain responsiveness and involvement of donors, medical and aid team determine the success of humanitarian relief operation performance [6]. Currently, a typical ERP (enterprise resource planning) system does not address those needs of emergency humanitarian relief functions [1][2]. Most of the information system for humanitarian logistic software (i.e., SUMA, LSS, HELIOS, LogistiX, Sahana, DMIS, FleetWave, HFOSS) developed today do not address some critical issues such as inventory management and supply planning [7][8]. Due to the nature that most disasters demand immediate response, what most NGOs are doing for emergency responses is mostly based on paper forms and excel spreadsheets. Typically, warehouse inventory level checking and material releasing requests are made via email and phone calls. Tracking of emergency humanitarian aid materials are manually maintained on spreadsheets. The lack of coordination and potential human errors can cause delays and wastes in resources, which jeopardizes the survival and the safety of affected people [6]. Many times detailed distribution reports are not possible to be generated until months after distributions have been carried out. And the accountability of humanitarian organizations may not seem to be fully transparent since it is not possible to generate status reports of any part of a supply chain at any given time [9]. Thus, a supply chain system that is tailored specially for emergency responses is much needed to improve efficiency [3], Purdue University school of Industrial Engineering and Catholic Relief Services are co-designing for this goal to develop an online supply chain management system for emergency responses.

II. SYSEM REQUIREMENT

The humanitarian aid emergency supply chain management system we plan to design needs to fulfil the following functional requirements:

- **Sourcing**: The system should be able to handle sourcing from of all types in emergency response: direct purchases from the local markets, regional

markets, and internationally via headquarters; in kind donations from other entities such as local government, UN agencies, and donors such as OFDA and DFID; in kind loans or swaps with other peer organizations; and internal transfers from global or regional prepositioned stocks, and between warehouses.

- **Item coding**: The system needs to be able to code common items into the system so that users can easily pull out those items the next time they need to purchase, and to better analyze demand trends for emergencies in general (e.g. what are the best items and quantities to preposition based on past records).
- **Inventory management**: The system should be capable of receipt, control and dispatch functions. The application will allow for warehouse transfers from primary to secondary warehouses, and with regular physical inventories and reconciliations.
- **Transforming**: Individual relief items converted into larger kit units for final provision to beneficiaries need to be accounted for either at warehouse levels or at distribution levels.
- **Tracking**: Any relief item could be tracked by its: item code, cost, donor source, purchase requisition number, purchase order, contract number, good receiving note number, good delivery note number, or distribution report. Tracking should be able to locate any item at (or near) real time within the supply chain or provide details of its status and planned disposition.

III. METHOD

The less time required to setup the system at the disaster area, the faster we can respond to emergencies. Thus, the system we are designing is a web-based online system coded in open source language - PHP, HTML, JavaScript CSS backed with SQL databases.

A. Architechture

The proposed cloud-based centralized database structure is composed of two components: the online web-based system as the main component, backed with the mobile component using mobile platform based data collecting tools (e.g: CommCare, iFormBuilder). The structure is illustrated in Fig.1. All user end devices with web browsers such as computers, tablets and smart phones can get access directly to our web-based online system with a CRS verified account via Internet. Those users at the disaster area or distribution sites with no Internet access will use mobile data collecting applications (e.g. CommCare, iFormBuilder) on mobile devices to collect data. Once those devices get connected to Internet, data collected on those mobile devices will be uploaded to the central database automatically.

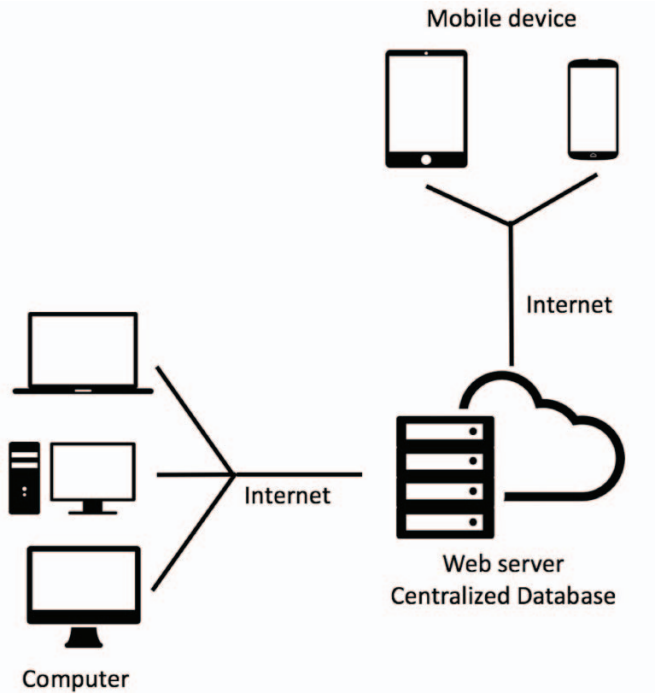


Fig. 1. Network Architecture

B. Key Features

- **Web - based**: Any device that has a web browser can use this system, including computers, smart phones, and tablets. No pre-installation is needed, and no software updates need to be performed on user-end devices. All maintenances and updates are done at the server side. This will increase the accessibility of the system.
- **Coded in open source**: The website is coded in open source language – PHP. As of 2016, 82% of all websites' server-side were coded in PHP [10]. And it was the most-used open source software within enterprises [11]. Thus, future maintenance and extension work can be easily performed.
- **Offline - compatible**: Often, distribution sites do not have consistent access to Internet. We use mobile data collecting application (e.g. CommCare, iFormBuilder) installed on the mobile devices as a data collecting tool for its offline function. Data will be stored locally on the devices until those devices get access to Internet and will be uploaded automatically. In this way, the system can function without internet at distribution sites and synchronize periodically when mobile devices return to the internet zone.
- **Cross - platform**: The system can be accessed from different operating systems, e.g. Windows, Mac OS, Android, iOS, etc.
- **Tracking**: The system can track any item from purchase order (donor source) all the way to the beneficiaries to whom it was distributed.

- **Automatic report generation**: The system will generate beneficiary receipt report and donor distribution report automatically after the distribution. Donors are able to see the detailed information about items that have been purchased such as the quantity, unit price and vendor information of each type of items. They are also able to know which area those purchased items have been distributed, how many beneficiaries have reached, and how many have been left at or returned to the warehouse. They can even know which beneficiary gets how many of what items at what time, and the transportation cost associated with those items. Accountability will be much improved. And all those detailed reports will be generated automatically by the system once the distribution is completed.
- **Online requests/approvals**: All sourcing/service requests will be submitted and approved online. The status of requests can also be viewed online. Privileges to submit, approve, and view requests is embedded under each user's login.
- **Online inventory status**: Most updated global inventory status across all different country programs can be monitored. Warehouses are now able to request items across different country programs. Individual country program supply chain is now formed as a global supply chain network.

C. *Workflow*

Within the design of the emergency response supply chain system, we have re-evaluated the needs of the users and re-design user's workflow. There are five main processes in CRS emergency responses. They are source, receipt, warehouse, dispatch and distribution. The document workflow is illustrated in Fig. 2. We will describe the function of each process along with the emergency response workflow in this section.

- Source: Sourcing requests are made during this process. There are 2 sourcing methods: procurement from outside CRS network and preposition stock from within CRS network. Each type of request requires different sequence of reviews and approvals. Once requests have been submitted online, all staffs with appropriate authorization will be able to review, approve, deny or check the status of the requests. Once the PRF is approved, a purchase order (PO) needs to be generated with detailed vendor information and

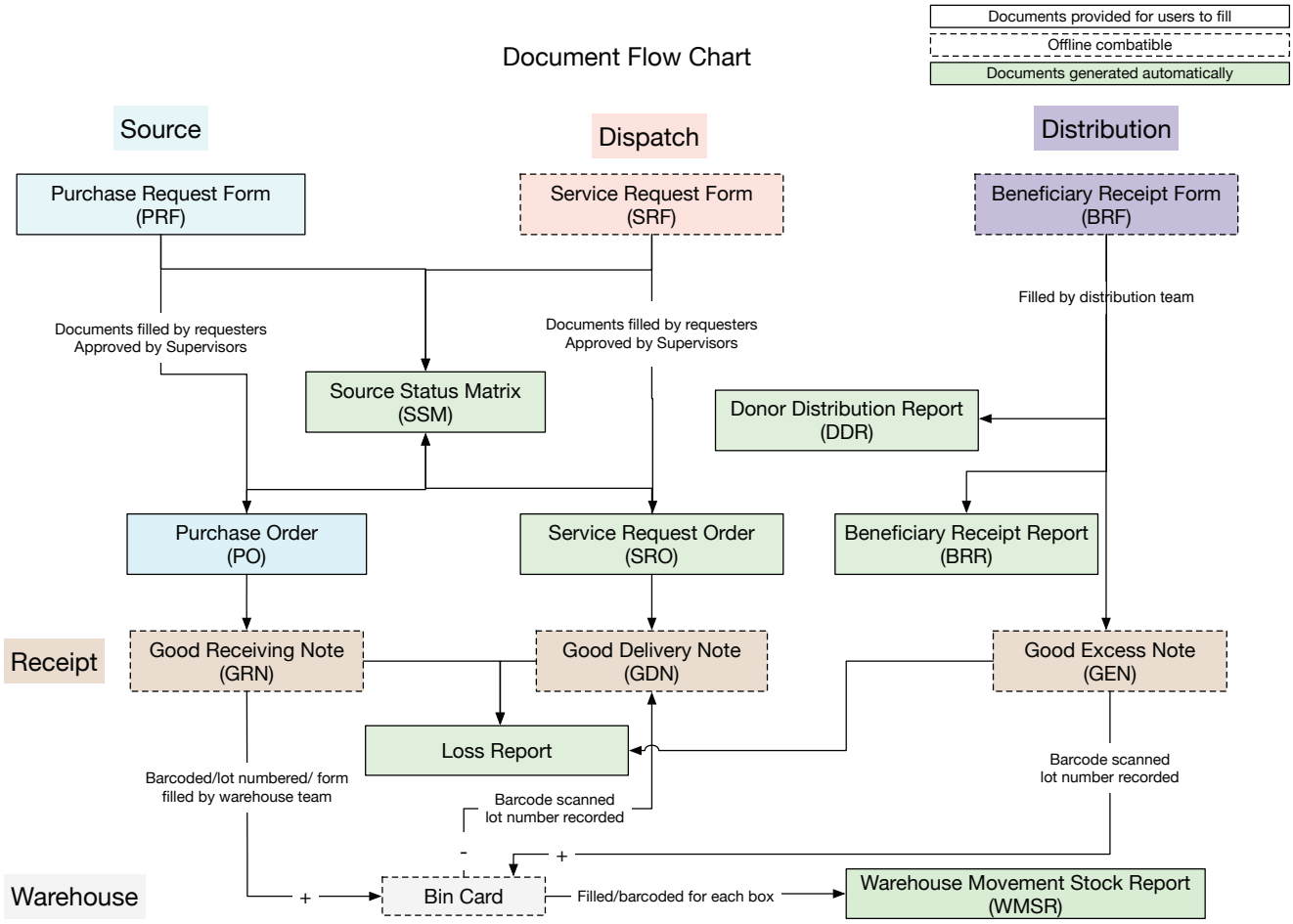


Fig. 2. Document flow chart

detailed product specifications. When the SRF has been approved, the system will generate a service request order (SRO) automatically because item information should be entered when those items came to the CRS system the first time.

- Receipt: There are 3 ways of receiving goods: receiving from outside CRS network (Good receiving note), receiving within CRS network (Good delivery note) and receiving returning excess goods from distribution (Good excess note). Those forms will be entered at the docking area via mobile devices such smartphones or tablets.
- Warehouse: The system has the same function as a typical warehouse management system for tracking inventory. Inventory stock levels can be checked across different warehouses within and across different country programs. Users are able to generate warehouse movement reports for accounting and tracking purposes.
- Dispatch: Warehouses within CRS network make service requests for items release by SRFs. Those forms, once approved, allow warehouse staff to dispatch items to a designated warehouse.
- Distribution: Distribution plans are used to request distributing items to beneficiaries. Beneficiary receipt report (BRR) and donor distribution report (DDR) will be generated automatically based on all the information collected in the database.

IV. Product

A. User Interface

We propose to develop the interface considering the user workflow and user-centered design principle.

We identified the minimum set of information needed from the user and minimized the fields that are required for each form. When migrating to electrical system from paper forms, we can take the advantage of retrieving information from the system after it was entered once. For example, there are redundant fields on the paper purchase requisition form (Fig. 3). All shaded areas now are eliminated in the new system. The electrical form (Fig. 4) has pull down menus and range checks as appropriate to reduce errors. Compared to the paper-based purchase requisition form, on the new re-designed form, purchase request date will be filled automatically by the system. Item information such as unit of measure and description is already coded in the item library. Users can choose items from an existing item lists. Requester information and signature will be filled automatically using the user login information. We do not need 3 hard copies for each department to sign. All people with appropriate authorization can review and approve those forms. Users can print forms online via web browsers with proper login.

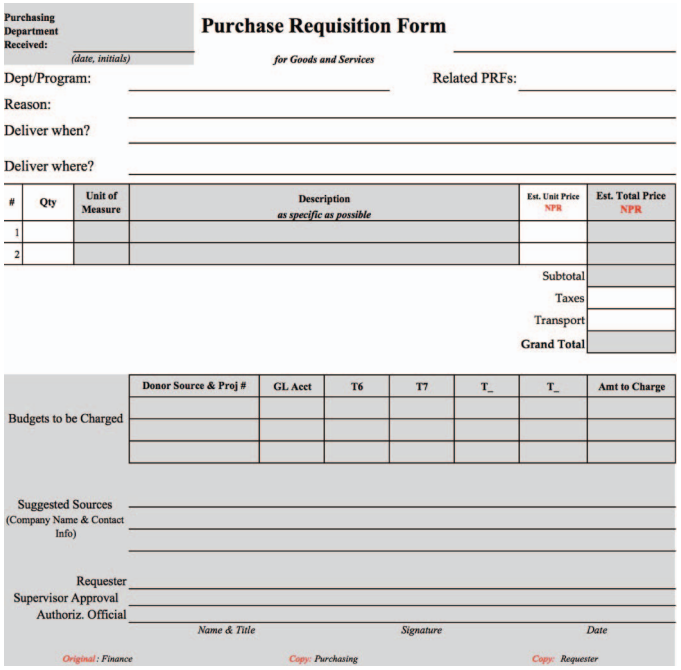


Fig. 3. Paper based purchase requisition form

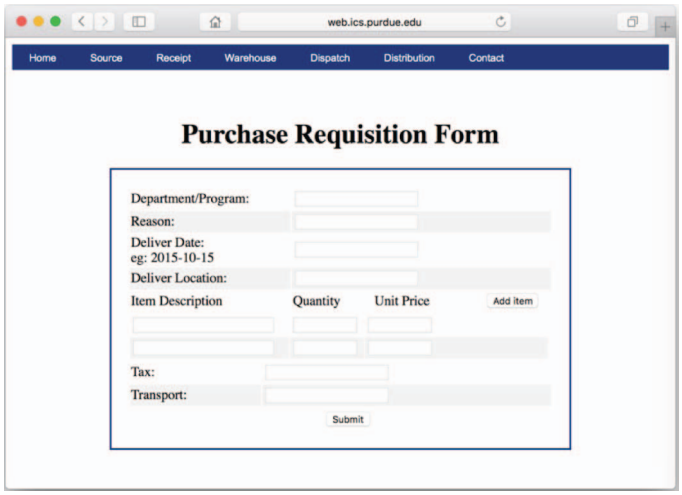
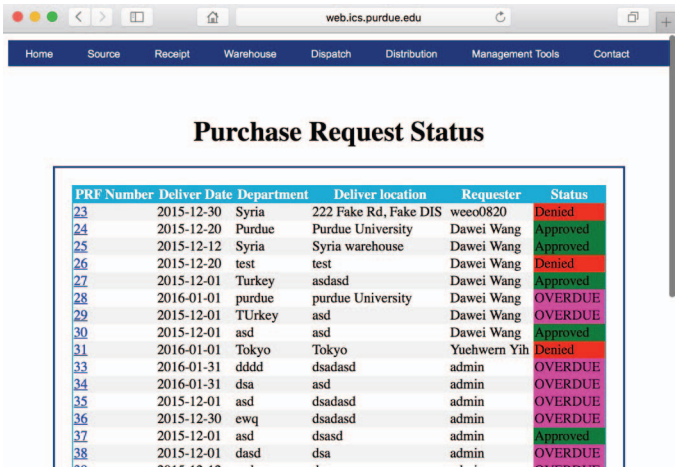


Fig. 4. Electrical purchase requisition form

B. Most updated status

Updated inventory levels and sourcing requests status can be viewed online (Fig. 5). People with appropriate authorization are able to approve or deny the requests once those requests have been submitted online. The information will be real-time if there is no interruption of internet

connection.



PRF Number	Deliver Date	Department	Deliver location	Requester	Status
23	2015-12-30	Syria	222 Fake Rd, Fake DIS	weeo0820	Denied
24	2015-12-20	Purdue	Purdue University	Dawei Wang	Approved
25	2015-12-12	Syria	Syria warehouse	Dawei Wang	Approved
26	2015-12-20	test	test	Dawei Wang	Denied
27	2015-12-01	Turkey	asdasd	Dawei Wang	Approved
28	2016-01-01	purdue	purdue University	Dawei Wang	OVERDUE
29	2015-12-01	TUrkey	asd	Dawei Wang	OVERDUE
30	2015-12-01	asd	asd	Dawei Wang	Approved
31	2016-01-01	Tokyo	Tokyo	Yuehwern Yih	Denied
33	2016-01-31	dddd	dsadasd	admin	OVERDUE
34	2016-01-31	dsa	asd	admin	OVERDUE
35	2015-12-01	asd	dsadasd	admin	OVERDUE
36	2015-12-30	ewq	dsadasd	admin	OVERDUE
37	2015-12-01	asd	dsasd	admin	Approved
38	2015-12-01	dasd	dsa	admin	OVERDUE

Fig. 5. Purchase request status page

C. *Mobile platform*

People can complete receiving notes such good receiving note at the docking area using mobile devices instead of desktops as shown in Fig. 6.

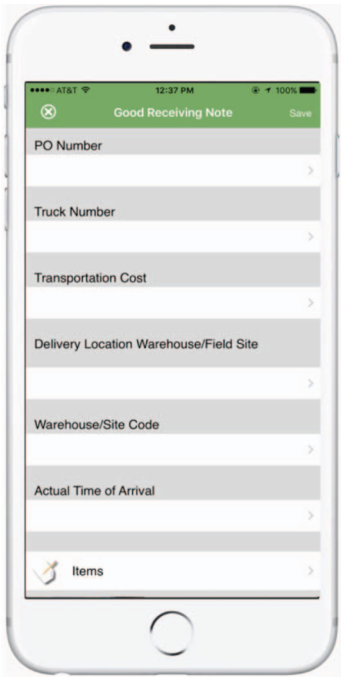


Fig. 6. Good receiving note

D. *Centralized database*

All items in the system can be tracked from the sourcing process all the way to beneficiaries. Tables are connected as shown in Fig. 7. Once an item is entered into the system, we are able to track all information including donor resource used to purchase this item, its location of storage, which truck transporting this item, which beneficiary receiving this item…etc.

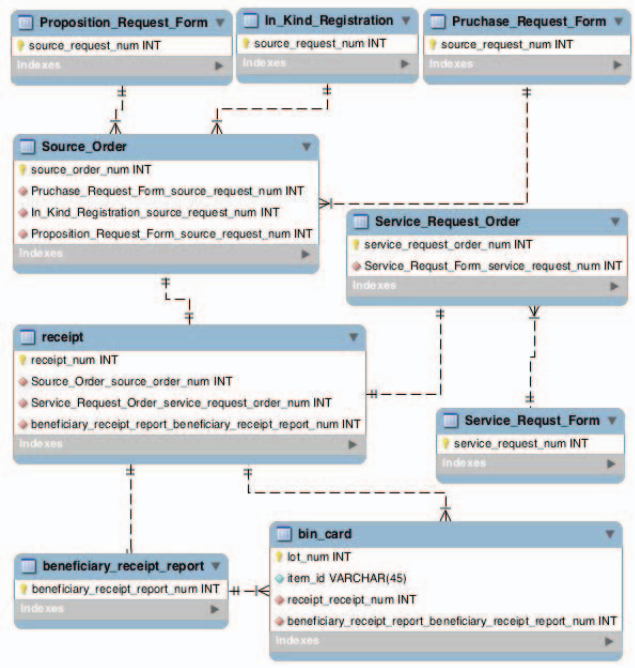


Fig. 7. Skeleton of database structure

Data collected via mobile devices with data collection tools (e.g. CommCare, iFormBuilder) will be uploaded to the centralized database via internet when it becomes available. We assume internet is available in the warehouse area (at least periodically), but not at the distribution site. The distribution site will operate in an area that is within the range of signal from the wireless router.

E. *Item coding*

To eliminate ambiguity and confusion in describing items, there is need for standard coding for each item. The new system provides the function to facilitate the development of item code library which will grow over time. Item specifications found in emergency programming manuals can be incorporated into this library.

Standard item coding can also reduce the amount of user inputs. As shown in Fig. 8, once an item has been coded into the library, the next time when the same item needs to be ordered, it can be retrieved easily from the database for purchase request forms or service requisition forms. Users do not need to input the same item information again for the same item more than once.

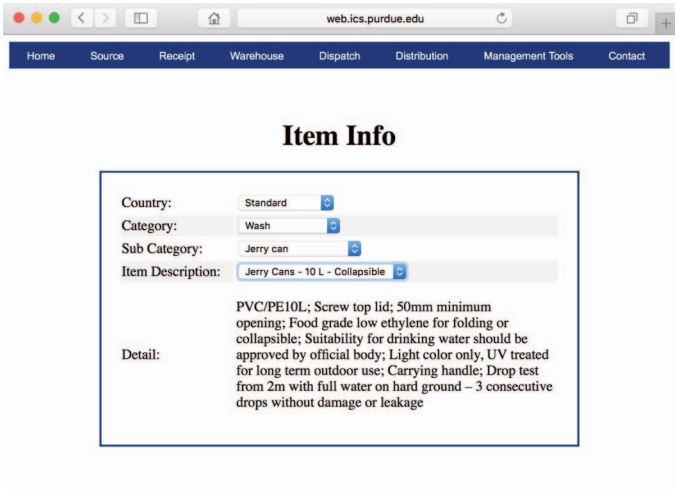


Fig. 8. Item coding example

V. Discussion and Future Work

We designed a Web-based, multi-platform, centralized, offline - compatible supply chain management system tailored specially for CRS emergency responses, though with the potential to be used by any similar INGO or LNGO around the world. This system under development is capable of making humanitarian aid material requests and approvals online. Near real-time emergency response inventory status across all country programs can be monitored online. Tracking from donor resources all the way to beneficiaries is possible now. Donor distribution reports and beneficiary receipts reports are generated automatically. After the development and deployment of this system, it will help coordinate between emergency response teams, reduce errors, and reduce distribution delays which should increase the efficacy and efficiency of emergency response operations in the future.

With the proposed system, we will be able to track items in the supply chains near real-time and collect status data. There is an opportunity in the future to improve the operations of the supply chain network with optimization model and simulation techniques. The entire global emergency response supply chain network can be studied to develop optimal strategies to maximize the efficiency and efficacy of emergency response operations.

Acknowledgement

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